I have found by experiment that the angles of the flint-glass prisms in this arangement cannot with advantage be made more than 90°, nor the outside crown-glass prisms less than 30°.

A Contrivance for a double Automatic Spectroscope, with compound Prisms on Mr. Grubb's plan. By Richard A. Proctor, B.A., Cambridge.

Mr. Browning having succeeded in constructing a double-battery spectroscope on the plan I submitted to the Society last December—with, however, a slight modification in the contrivance for automatic adjustment—I am encouraged to believe that the plan I am now about to describe will be found feasible; though certainly the difficulties which the optician will have to surmount are by no means slight.

I propose the substitution of Mr. Grubb's compound prism for the single prisms in my double battery, the single intermediate prism being replaced by an intermediate compound prism, shaped as shown in the accompanying view (fig. 1) of the complete

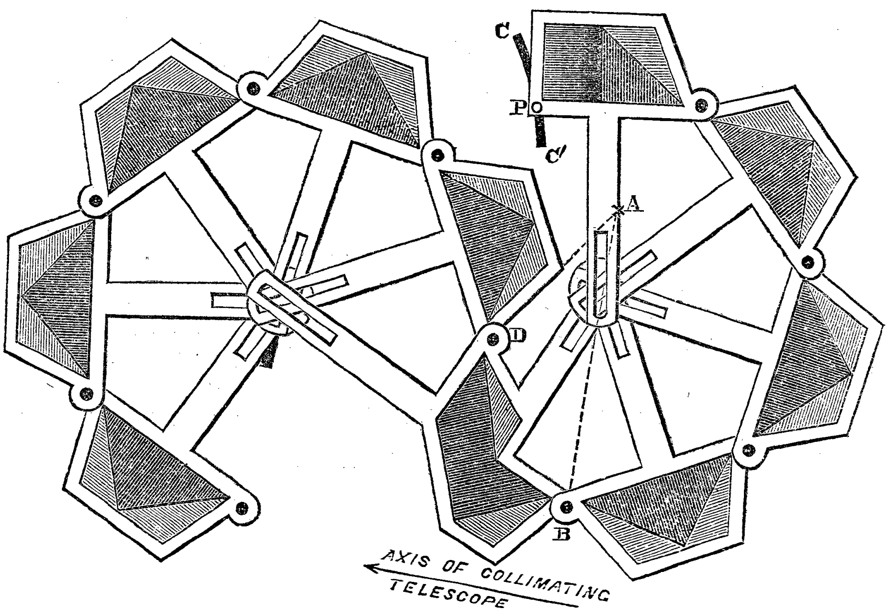


Fig. 1.

double battery. (The pivots on which the slots work have been omitted by the engraver.) This view, with the description given in my former paper serves to explain how the automatic adjustment is secured. But it will be noticed that the radial bar and the long slotted bar of the former description are removed. As I partly suspected when I suggested their use, they fail to communicate motion effectively to the second battery. The reason is easily seen: they work on that end of the second battery which

moves the most slowly, that is, where the leverage is least. When Mr. Browning found, on trial, that this was the case, another method—which, like the former, is theoretically exact—suggested itself to me. It is a property of the double battery that each prism of one battery has its base at right angles to some one prism of the other battery. Hence, if by means of a slotted T-square bar, this relation could be impressed on two corresponding prisms of the separate batteries, the adjustment would be mathematically exact. On trial, this method was found also to fail; and no other mathematically exact extension suggesting itself to me (and time pressing), I agreed that in the specimen double battery the last prism of the second battery should be carried by a simple radial motion making it travel as nearly as possible on its proper curve.*

* I should have preferred a cam, but Mr. Browning stated that there were practical objections. The theoretical advantage of a cam is, that the pivot p can be made to travel in the true curve, as C C′ (fig. 1). And in order to determine this curve, a construction founded on the plan first suggested by me could be adopted. Thus the dotted lines D A, B A show the position which the removed bars would take up. Now the motion of the first battery would bring these lines into position; and if then the slotted bars of the second battery were carried by means of their common pivot until this pivot was just centrally over the line A B, then the pin P would be in its proper place, which could readily be marked. Several marks being thus made, the proper figure of the cam C C′ would be determined, and more accurately, I conceive, than by endeavouring merely to make the amount of closing of the second battery equal to that of the first. That the curve C C′ is not circular will be obvious to every mathematician; nor is it difficult to show that it deviates enough from circularity to render it advisable that, in place of a radial movement, a trammel-movement should be used (to give the varying curvature), if the cam is absolutely rejected.

The equation to the *locus* along which the pin P should travel can be readily determined. But the *nature* of the curve can be shown without obtaining the equation itself. For the curve may be shown to be similar to that traversed by the last angle of a single battery of six prisms; and the form of the equation to this last-mentioned curve may be obtained at once—

Thus, let A B, B C, &c. be the bases of six prisms forming a single automatic battery. Then it is easily seen that in all positions these bases are successive chords of a circle having its centre O on a fixed line A O through A. Let P be the last angle, and draw P M perpendicular to A O produced. Put

$$\mathrm{PM} = x \text{ and } \mathrm{AM} = y;$$

and let the radius A O be R, and the base of each prism $2a$. Then,

$$\text{angle AOP} = 12 \sin^{-1}\left(\frac{a}{\mathrm{R}}\right)$$

$$y = \mathrm{R}\,(1 + \cos \mathrm{POM})$$

$$= \mathrm{R}\left\{1 - \cos 12\left[\sin^{-1}\left(\frac{a}{\mathrm{R}}\right)\right]\right\} \qquad \text{(i)}$$

$$\text{and } x = \mathrm{R} \sin 12\left[\sin^{-1}\left(\frac{a}{\mathrm{R}}\right)\right] \qquad \text{(ii)}$$

Eliminating R between (i) and (ii), we shall obtain the equation to the *locus* of P, and the curve will clearly be of a very high order. It is, in fact, a some-

The proper shape for the intermediate prism is easily deduced. For let A D C B (fig. 3) be the half of one of Mr. Grubb's compound prisms. Then the light which is passing parallel to A B must be totally reflected by a face B E inclined at an angle of 45° to its course. We must therefore take B C E a half square. Then, that the exit of the light may be on a course exactly similar to its entrance, we must add the half of a compound prism C E G F exactly similar to B C D A. Thus the construction for determining the section A C F E B of the flint portion of the intermediate prism is obtained very readily by sole reference to the figure of half a compound prism.

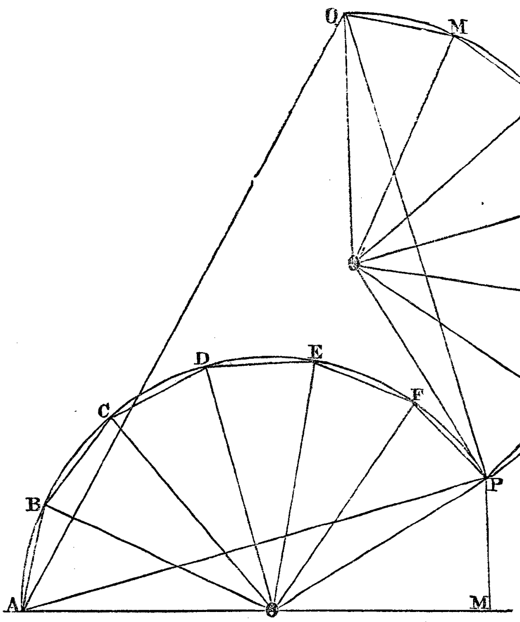
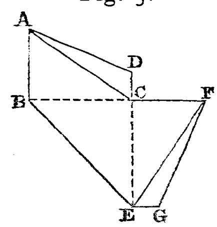


Fig. 2.

Fig. 3.



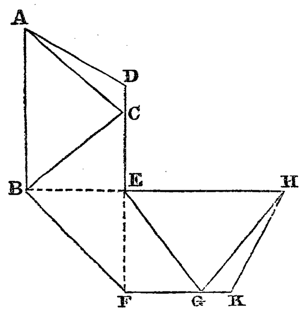


Fig. 4.

Note also that, if a symmetrical compound prism consist of more parts than three, a similar construction will give the proper shape for an intermediate compound prism in a double battery of such prisms. Thus, let A D C E B (fig. 4) be one half of a compound prism formed of five prisms; then the construction given in fig. 4 shows the proper section for an intermediate prism. B E F is half a square, and the portion E F G K H is exactly similar to the half-compound prism A D C E B.

The battery pictured in fig. 1 would give about twice the dispersion given by my double battery of single prisms: in other

what peculiar spiral. Now, if we add a second battery of the same number of prisms (an intermediate prism giving one total reflexion), we obtain the base lines P G, G H, &c., the centre O′ of the circle on which they lie being a tangent to the circle A D P. And it is easily seen that the last angle Q will always be so placed that A P Q is half a square. Hence the locus of Q is precisely similar to the *locus* of P, but enlarged in the proportion of $\sqrt{2}$ to 1, and tilted round A in the positive direction of angle-measurement, through 45 degrees.

words, it would give a dispersion equal to that given by 36 equilateral prisms of heavy flint glass. It will be understood that the light is taken twice through the double battery, returning at a higher level, after exactly the same fashion as in the battery described by Mr. Grubb in the December number of the *Monthly Notices.*

Observations of Mars, with Drawings.
By John Joynson, Esq.

The accompanying drawings of the planet *Mars*, as it has been seen during the late opposition, are arranged so as to exhibit its aspect at regular intervals of thirty-seven minutes. There are, in consequence, four more in number than those in the sets already sent to the Society for the oppositions of 1862, 1864, and 1867; but they can be easily compared with them, as there has been but little change in the appearance of the planet since the last opposition.

It will be noticed that the aspect of the planet is entirely changed in about ten diagrams, or about every six hours, showing that we can only see about one-fourth of the planet, or about half the true disk at one time; about one-eighth on each limb is hidden by the rotundity of the planet. This is confirmed by the fact that the aspect changes slower at the neighbourhood of the limbs than the same part does when it gets about the centre of the disk. The present arrangement enables any one to see at once what parts are on opposite meridians, as one hemisphere is represented by twenty diagrams.

The planet has been apparently tilted over, so as to bring the North Pole more directly towards us, though the effect is more perceptible on the southern limb than about the pole itself. The North Polar snow has been of much smaller extent than it was at the last opposition, and has had very much the appearance of that at the South Pole, as seen in 1862. It has not been quite on the limb, as it has appeared somewhat larger on one side than on the opposite: though it has sometimes, even on both, appeared perfectly round, owing to its smallness and brightness. There is only one other remark to make as to any apparent change on the disk, and that is, that the watery projection from the North Polar snows seen about the 22nd March has been much larger than at the last opposition; indeed the whole disk about the pole has been darker than previously.

The general colour of the disk (saving the band and the channel from it to the circumpolar waters) has been yellowish, with a brownish tinge towards the pole. But it is difficult to say what the real colour is, for the same part of the disk has varied from night to night from dark-yellow to very nearly white, according to the state of our own atmosphere.